as that of the lens forwards. By the time the lens reaches the edge of the danger-arc the screen will have been pushed to the top of the inclined plane, and the full beam of light coming from the now entirely uncovered lens will be pointing in the required line of cut-off which is the border of the danger-arc. But whenever the further revolution of the apparatus causes the snug to pass clear of the edge of the screen so as to free it from pressure, it will immediately run back again to its original position in front of the lens, so as to prevent any light being now sent forwards. If that light were not at once intercepted part of it would, by the movement of the frame, begin to pass across the line of cut-off, so as to be seen within the danger-arc. By this continued reciprocative movement of the screen as lens after lens comes round, the same effect will be successively produced, and the light will always be cut off in the line of obscuration as sharply as in the case of a fixed light, so that the flashes will never be seen within the danger-arc.

In cases where the light has to be cut off on both sides of a danger-arc a similar reciprocating screen is as applicable to the lenses when passing out as when passing into the danger-arc. But in this case the lens, on leaving the danger-arc, will take the screen round with it up an inclined plane until the axis of the lens is parallel to the line of cut-off, when the screen will recoil and the light become visible with full power in the line of cut-off.

A small spherical mask placed inside of the apparatus may be made to produce the same effect by reciprocating between the lenses and the flame. When the danger-arc is of small amplitude the screens, which must always be as broad as the lens, might come in the way of the light passing over the safety-arcs. To obviate this, cloth curtains might be made to wind up on vertical rollers similar in construction to those used for ordinary house-blinds.

THOMAS STEVENSON

CHLOROPHYLL[1]

AN account was given in NATURE, vol. xxi., p. 85, of Prof. Pringsheim's first publication on this subject. He had then found that exposure to intense light for a few minutes causes the chlorophyll-corpuscles contained in the cells of plants to lose their green colour; he also pointed out that this effect is produced not by heat but by light, and only in the presence of oxygen, and further, that the highly refrangible rays of the spectrum are those which are principally concerned in it. He also announced the discovery in the chlorophyll-corpuscles of a substance termed Hypochlorin.

The paper now under consideration gives a full account of all the observations and experiments which he has made up to the present time, and he considers that they tend to confirm the conclusions at which he had previously arrived. It will be well, before entering upon a discussion of the very difficult questions which are raised, briefly to enumerate the principal new facts which he now brings forward.

In the first place, he is able to throw some light upon the intimate structure of chlorophyll-corpuscles by means of a new method for investigating them. This method consists in treating them with a dilute acid (*e.g.* 1 vol. of glacial acetic acid to 2 of water, or 1 vol. of picric acid to 3-6 of water, or 1 vol. of sulphuric acid to 20-40 of water, or 1 vol. of strong hydrochloric acid to 4 of water), or warming them in water, or exposing them to the action of steam. The effect of this treatment is to cause the escape of the chlorophyll from the corpuscle, together with certain fluid or semi-fluid substances which accompany it, in the form of viscid drops, leaving the ground-substance of the corpuscle as a colourless, apparently protoplasmic, hollow sphere, with a much perforated wall.

These viscid green drops, when produced by the action of warm water or of steam, appear to consist of an oil which holds the chlorophyll and other substances in solution. When they are produced by means of a dilute acid, they appear to contain a substance which is not present when they are extracted by warm water or by steam. Certain dark brown masses make their appearance which are of a tolerably firm consistence and of varying form. These gradually become harder, and assume a crystalloidal appearance, probably, as Prof. Pringsheim suggests, in consequence of a conversion into resin of the oily matter which is present; but it is by no means the whole of the substance which thus solidifies, but only a certain constituent of it. The colour of the mass is doubtless due to the presence of altered chlorophyll, and this may affect even the crystalloids, but they may be obtained colourless. It is to the substance which assumes the crystalloidal form, or rather to some substance pre-existent in the chlorophyll-corpuscle from which these crystalloids are derived by the action of the acid, that Prof. Pringsheim gives the name of Hypochlorin.

He meets the doubts that may arise as to the chemical individuality of this substance, as also the suggestion that it may be a product of the alteration of the chlorophyll, by pointing out that it cannot usually be obtained at any one time from all the corpuscles of a given cell. It is therefore a substance which, as it is present in some and not in others, cannot be derived from chlorophyll which is present in them all, and which probably bears some definite relation to the metabolic processes going on in the corpuscles.

Since no hypochlorin can be obtained from cells which have been warmed in water or acted upon by steam, it appears that this substance is decomposed by heat.

After giving a detailed description of the arrangement of the apparatus used in his observations, Prof. Pringsheim goes on to give an account of the effects produced by exposure to intense light in the different parts of which the cell consists. He again insists that none of the following phenomena can be the results of excessive heating of the object, for he found that cells not containing chlorophyll (*e.g.* colourless zoospores) could bear the exposure for half-an-hour without injury, and further, that the phenomena were produced more readily by blue or green light than by red light which has a much greater heating effect. The principal phenomena observed are as follows:—

1. The colouring-matter.

The chlorophyll-corpuscles lose their colour in a few minutes, but this does not take place when oxygen is not present, nor in red light. There is no trace of chlorophyll left in the corpuscles. Prof. Pringsheim is therefore of opinion that its decolorisation is a phenomenon of oxidation, and that the products are gases. Further, this disappearance of the chlorophyll is not prevented by the absence of carbonic acid gas. The corpuscles which have lost their green colour do not regain it, although the cell in which they are contained, still continues to live; on this account Prof. Pringsheim regards the decomposition of chlorophyll as a pathological and not as a normal process.

Colouring matters, other than chlorophyll, which occur in the cells of plants, are likewise decomposed, but not all of them. Thus, the blue pigment of the Phycochromaceæ, the brown of Fucus, the red of the Florideæ, the orange of the corolla of Calendula, the blue in the cells of the staminal hairs of *Tradescantia virginica*, disappear, but the blue pigment in various flowers is not decomposed by exposure to intense light.

2. The ground-substance of the chlorophyll-corpuscles and their contents.

If a cell of Nitella or of Spirogyra be killed by the action of heat, for instance, the chlorophyll-corpuscles of the one and the spiral band of the other will absorb water and swell up. If the cell has been killed by prolonged exposure to light, no such absorption of water will take place.

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[1] "Untersuchungen über Lichtwirkung und Chlorophyllfunction in der Pflanze," by Prof. N. Pringsheim (*Jahrbücher für Wiss. Bot.*, Bd. XII., Heft 3: Leipzig, 1881).

Prof. Pringsheim mentions starch, oil, and tannin as commonly occurring in the chlorophyll-corpuscles[1]; these substances, which contain a considerable proportion of oxygen in their molecule, are not affected by the action of light.

3. Hypochlorin.

No trace of this substance can be detected in cells which have been exposed.

4. The protoplasm of the cell.

The turgidity of exposed cells is lost; the protoplasm readily allows colouring matters to pass through it, and treatment with plasmolytic reagents produces no contraction. In a long cell, part of which has been exposed to the action of light, it is only the portion of the protoplasm which has been exposed that exhibits these alterations in its properties. Moreover, these changes are apparently accompanied by a perceptible loss of substance.

A brief exposure causes an arrest of the rotatory movements of the protoplasm in cells which exhibit it. If the exposure has not been prolonged, these movements will recommence after a time. If a portion only of such a cell be exposed for not too long a time, the movements will be arrested in the exposed portion, whereas it continues in the rest of the cell.

5. The cell-wall.

The only effect which the exposure produced on cell-walls appears to have been that the cells of the more delicate filaments of species of Spirogyra and Mesocarpus become isolated.

The following are the general conclusions which Prof. Pringsheim draws from the facts which have been stated above. He concludes that the injurious effects produced by the exposure of a cell to intense light in an atmosphere containing oxygen, are due to an increased oxidation of certain substances which are essential to its life. The rays which are active in this process are not those which reach the interior of the cell after having passed through the chlorophyll-corpuscles, but those which reach it directly. He finds, it is true, the cells which do not contain chlorophyll are, on the whole, less sensitive to the action of light than those which do contain it, but there are no grounds for believing that this greater sensitiveness is due to the absorption of any light-rays by the chlorophyll. On the contrary, the presence of chlorophyll in a cell seems rather to diminish than to increase the oxidising action of light. Facts are adduced to show that chlorophyll exercises a protective influence in this respect, and it is further pointed out that the death of the cell, when exposed to intense light, takes place *before* the complete decolorisation of the chlorophyll-corpuscles has been effected. The greater sensitiveness to the action of light of a cell containing chlorophyll is ascribed to the presence in it of the readily-oxidisable products of its assimilatory activity, and of these hypochlorin is the most important.

Prof. Pringsheim's theory of the function of chlorophyll is, then, (1) that the respiration of a cell is increased by exposure to light; (2) that, in consequence of the absorption which takes place when light passes through chlorophyll, the presence of chlorophyll in a cell tends to counteract the influence of light, so that, when the light is not intense, the respiration of the cell is so far diminished that processes of reduction can take place within it, but when the light is very intense the chlorophyll itself undergoes decomposition, and the death of the cell is brought about by the excessive oxidation of certain of its essential constituents.

After having stated his own views, Prof. Pringsheim proceeds to criticise the current hypotheses concerning the function of chlorophyll. The first of these is the one according to which chlorophyll is itself converted into carbohydrate in the assimilatory process. It is not easy to understand, from a chemical point of view, how such a conversion can be effected in the plant, and it becomes quite impossible when it is shown, as Prof. Pringsheim has done, that chlorophyll does not undergo any perceptible change when it is exposed to light in an atmosphere containing carbonic acid but no oxygen. The second relates to the absorption-spectrum of chlorophyll. The question naturally arises as to whether or not the rays which chlorophyll absorbs are those which effect the reduction of carbonic acid and water in the chlorophyll-corpuscle. That it must be answered in the negative is clear when it is borne in mind that the maximum, of the decomposition of carbonic acid does not coincide with the maximum of absorption in the chlorophyll-spectrum. From what source, then, is the energy derived which is necessary for this reduction? It is derived, according to Prof. Pringsheim, from light-rays absorbed, not by the chlorophyll, but by the other cell-contents. He is of opinion that the chlorophyll takes no direct part in this process.

The next question which is dealt with is the existence of an optimum intensity of light for the decomposition of carbonic acid. Prof. Pringsheim does not consider that this is the intensity which effects the greatest evolution of oxygen, for, from his point of view, the amount of oxygen given off at any time is the resultant of the action of two distinct processes, respiration and assimilation, both of which are affected by the intensity of the light. He concludes that, so far as an actual gain of carbon is concerned, there is no general optimum intensity. He applies this mode of reasoning also to the question of the relative activity of the different rays of the spectrum in the process of assimilation. The green and yellow rays have been found to be more active than the blue, because, as he points out, they are not absorbed to the same extent by the chlorophyll, and not because they are endowed with any special reducing power. Finally, he proceeds to the discussion of the fact that the volume of an atmosphere in which green plants are exposed to light remains constant. This fact has led to the conclusion that, since the volume of carbonic acid decomposed and of oxygen exhaled is the same, the substance formed in the process is a carbohydrate. Prof. Pringsheim's inference from this fact is very different. He argues that since oxidation and reduction are going on simultaneously, the substance formed contains a smaller quantity of oxygen than a carbohydrate,—in fact a quantity which is smaller by just that amount of oxygen which has been used up in respiration.

Stated in the briefest possible manner, Prof. Pringsheim's principal results are as follows:—

1. That the presence of chlorophyll favours the assimilatory activity of the chlorophyll-corpuscle in consequence of the absorption, by the chlorophyll, of light, which would promote the respiratory activity.

2. That hypochlorin is the substance which is the first visible product of this assimilatory activity, and that the other substances (starch, glucose, oil, tannin) which are found in chlorophyll-corpuscles are derived from hypochlorin by oxidation. This conclusion is based upon the general occurrence of hypochlorin in chlorophyll-corpuscles, upon the fact that the amount of hypochlorin in a corpuscle varies inversely as the quantity of starch which is present, and upon the observation that hypochlorin cannot be detected in seedlings until they have been exposed to light of such an intensity as to enable them to assimilate.

It is of interest to note that hypochlorin makes its appearance at the later stages of germination in seedlings of various species of Pinus which have grown in the dark, inasmuch as it has long been known that these plants become green in darkness.

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[1] He quotes the observations of Briosi to prove that oil, and not starch, is the substance which is formed in the chlorophyll-corpuscles of the Musaceæ, without being aware, apparently, that Briosi's results have been shown to be incorrect by Holle and Godlewski ("Flora," 1877).

This paper cannot be regarded as other than a most important contribution to our knowledge of the physiology of plants, and it will be readily admitted that Prof. Pringsheim's theory of the function of chlorophyll is at least as satisfactory as any which are now current. But although the number of facts upon which the theory is based is large, yet the evidence in favour of it can hardly be considered to be complete at present; there are certain points which require further elucidation. For instance, Prof. Pringsheim regards the chlorophyll of a corpuscle as undergoing no change under ordinary circumstances, but it is difficult to reconcile this view with the fact that an alcoholic solution of chlorophyll loses its colour under the same circumstances. Then again, as to the source of the reducing energy in the process of assimilation, if the rays absorbed by the chlorophyll are not directly concerned in it, it is most desirable that more information should be obtained as to the nature of the rays which are active, and as to the particular cell-contents which absorb them. Further, the correctness of the principle that an increase in the intensity of light to which a cell is exposed produces an increase of its respiratory activity, needs more direct and general experimental confirmation than is given here. In his views as to the respiratory function, he appears to insist too strongly that the chlorophyll-corpuscles are to be regarded not only as assimilatory, but also as respiratory organs. It is not easy to see that any of the observations which he gives in this paper directly suggest such a view; on the contrary, they tend rather to show that exposure to intense light increases oxidation in the *whole* of the protoplasmic cell-contents. Prof. Pringsheim evidently desires to bring out that hypochlorin is *the* substance which undergoes oxidation in the cell, and since it is present exclusively or nearly exclusively in the chlorophyll-corpuscles, he considers that these bodies are the especial seats of the respiratory process. His observations, however, do not warrant this conclusion; what they prove is that the hypochlorin in the chlorophyll-corpuscles is oxidised when they are exposed to intense light in an atmosphere containing oxygen, and that certain changes (including a loss of substance) take place in the rest of the protoplasm, in consequence, doubtless, of the excessive oxidation of some substance or substances which it contains. His view may be fairly met with the *à priori* objection that it is highly improbable that the same organ should be the seat of two such opposite functions as respiration and assimilation. The true physiological significance of the chlorophyll-corpuscles becomes apparent when it is borne in mind that assimilation does not take place in cells which do not possess them, whereas respiration proceeds actively, perhaps most actively, in such cells.

And, finally, as to hypochlorin, it is to be hoped that a method will be devised for the extraction of this substance in such quantities as to allow its properties to be studied and its chemical composition to be ascertained. The curious fact that hypochlorin cannot be detected in plants which are not distinctly green (Diatomaceæ, Fucaceæ, &c.), is worthy of further investigation.

These desiderata may perhaps be supplied in the future publications on this subject which Prof. Pringsheim promises.

SYDNEY H. VINES

NOTES

WE take the following from the *Times*:—At their meeting last week the President and Council of the Royal Society selected, from the whole number of fifty-two candidates for the fellowship, the following fifteen to be recommended to the Society for election at the annual meeting on June 2 next:—W. E. Ayrton, H. W. Bates, J. S. Bristowe, W. H. M. Christie, G. Dickie, A. B. Kempe, A. Macalister, H. McLeod, J. A. Phillips, W. H. Preece, B. Samuelson, M.P., B. B. Stoney, R. H. Traquair, Rev. H. W. Watson, C. R. A. Wright.

A *conversazione* of the Society of Telegraph Engineers was held in honour of Prof. Helmholtz in the rooms of University College on Monday night. Among those who were present to meet the guest of the evening were many eminent English men of science. Many of the members of the Society and other had lent instruments and apparatus showing some of the purposes to which electricity has recently been applied, and also the means by which electrical research is still being carried on. On entering the College grounds the visitors saw a very pretty effect caused by one of Mr. Crompton's electric lights, which had been placed on the top of the portico. The reception-room itself was lit up with little incandescent electric lamps on Mr. Swan's principle. They were arranged in bunches of three or four in ground glass globes suspended from the ceiling, and in fact at first sight they looked like very brilliant gas-burners, no wires being visible. On each side and down the centre of the room were placed tables on which were arrayed all the newest inventions in electrical science. On one it was demonstrated how perfectly easy it was to manage Mr. Swan's lamps; taking one lamp out of the stand and putting in a new one occupying only a few seconds, there being no binding-screws or switches to attend to. Perhaps the most interesting experiment of the evening was the transmission of pictures of natural objects by telegraph, the picture of a butterfly being most beautifully transmitted by means of a selenium plate. This was shown by Mr. Shelford Bidwell's telephotographic machine. Mr. Latimer Clark exhibited some rare books on electricity and magnetism, autographs and portraits of eminent electricians; also a portion of the original telegraph line which was laid by the late Sir Francis Ronalds in 1816, with the original model of Ronalds' telegraph, the original type cast for the Morse telegraph, with autograph of Prof. Morse, and a portion of line laid by W. F. Cooke in 1837. Mr. Cotterell of the Royal Institution exhibited a very delicate mercury electrometer on Lippman's principle, belonging to Prof. Dewar; and Mr. Robert Sabine performed some pretty experiments illustrating the cause of the motion of the mercury. Mr. Stroh showed the beautiful apparatus made by him to illustrate Prof. Helmholtz's vowel theory, and Mr. Preece performed several experiments in explanation of the remarkable sounds produced by intermittent light on solid, liquid, and gaseous matter. Mr. George Lund, of the firm of Messrs. Lund and Blockley, exhibited some synchronous clocks for the London, Chatham, and Dover Railway Company for coupling up two ordinary telegraph lines at 10 a.m., in order to send the time current. They also applied to the clock a novel automatic arrangement of their own invention, by which, at two minutes to 10 a.m. daily, the current will ring a warning bell, couple up and block against false currents two ordinary telegraph wires, then at 10 a.m. the clock sends the time-current of two seconds' duration, giving time to the clocks in circuit. Immediately upon the termination of the two seconds' current the lines will be automatically re-established as distinct lines for their ordinary telegraph purposes. All present were pleased to have the opportunity of inspecting Prof. Kennedy's engineering laboratory, where the machine for testing the strength of materials up to fifty tons was seen in operation, and various pieces of brass and copper were tested. The machine-tools were in operation, and a steam-engine of peculiar construction driving them. We look forward with interest to the scientific results we may expect to be brought to light with the testing-machine. The President (Prof. Carey Foster) showed some interesting electrical instruments; Mr. Richard Anderson a portable galvanometer for testing lightning-conductors; Profes-